300 MM ELECTROMAGNET WIGGLER FOR ELBE

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Abstract

In the past two years, a number of insertion devices have been designed, assembled and tested at Danfysik. They are used for a variety of applications at free electron lasers and synchrotron radiation facilities. In this paper, we describe the 300 mm electromagnetic wiggler, to be used at HZDR Dresden

INTRODUCTION

Danfysik[1] has the ability to deliver all types of insertion devices, including in-vacuum devices, out of vacuum devices, and Apple-II type devices[2,3]. In this short paper, we describe the latest electromagnetic wiggler delivery, this time to Helmholtz-Zentrum Rossendorf, in Dresden.

MAGNETIC DESIGN AND RESULTS

Danfysik received the order to design and build a 300 mm period, fixed-gap, electromagnetic wiggler. This wiggler will serve as a source of narrow-band THz radiation in the 100 μm to 10 mm range[4]. It will be operated with electron beams of 15 to 40 MeV, with beam currents up to 1.6 mA.

Magnetic Design

The wiggler was modeled both in RADIA[5] and in Vectorfields OPERA. RADIA was used to get the end termination correct, whereas Vectorfields OPERA was used to double-check the iron losses to make sure we had sufficient current. The field in the pole was approaching 1.9 T, so we felt quite confident that a minimum K_{RMS} of 7.5 could be reached. To achieve the specified double focusing action, we designed a small groove into all of the poles, except the thin end poles. In this way, we achieved a field increase of 0.2 % at 20 mm.

Due to the harsh demands for electron trajectory straightness, the wiggler is powered by 5 independent power supplies, such that the two end poles can be controlled independently, at the entrance and exit, while the central poles are on a common supply. The magnet power supplies are all built by Danfysik, and are summarized in Table 2.

For this projet, it was crucial that the magnetic pole centers were periodic, including the end pole pieces. This required careful optimization of the end sections, where there was

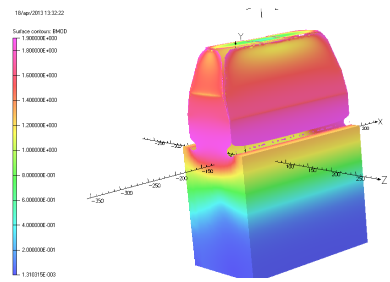

Figure 1: Modelling of a central pole using Vectorfields OPERA. The field is shown up to 1.9 T.

Table 1: Electromagnet Wiggler Specifications

Period Length	300 mm
Number of full-size periods	8
# poles, including end poles	16+2
K_{RMS}	7.76
Peak field	0.38 T
Minimum clear gap	102 mm
Field flatness	+0.2 %

Table 2: Summary of Magnet Power Supplies

	MPS type	Quantity	Stability	Max. Current
Central poles	854	1	10 ppm	625 A
Large end poles	854	2	10 ppm	235 A
Small end poles	9100	2	10 ppm	200 A

Magnetic Cycling

It was crucial to determine a “washing” procedure, before any fine tuning of the trajectory was possible. This is summarized in Table 2. After this was determined, the fine tuning of the trajectory was quite effective. The washing sequence was: wash End-1 pole (end at set current), wash End-5 pole (end at set current), wash End-2 pole (end at set current), wash End-4 pole (end at set current) and then wash main poles (end at set current).

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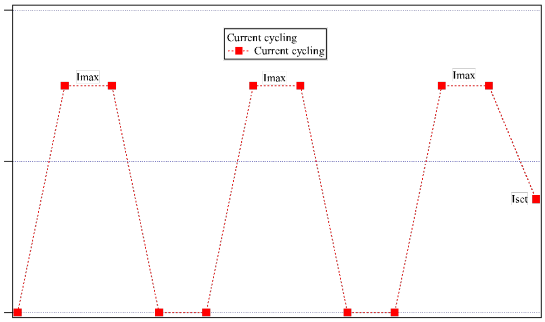

Figure 2: Magnet cycling of individual magnet pole systems.

Magnetic Results

At 625 A, we achieved a K_{RMS} value of 7.76, which is above the specified 7.5. We also found an RMS phase error of 1.23°. The electron straightness was found to be excellent, as is seen from Fig.3 and Fig. 4.

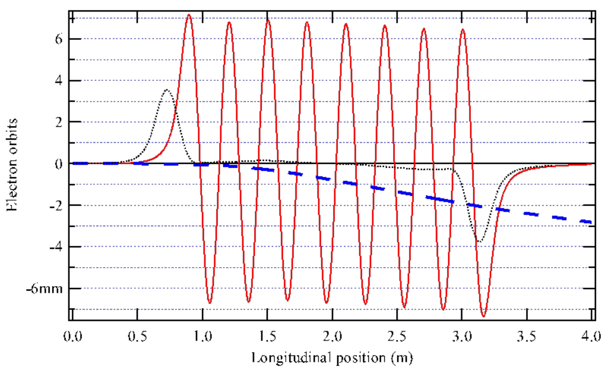

Figure 3: Simulated electron trajectory based on Hall measurements, for K_{RMS}=7.76. Electron energy is set to 40 MeV.

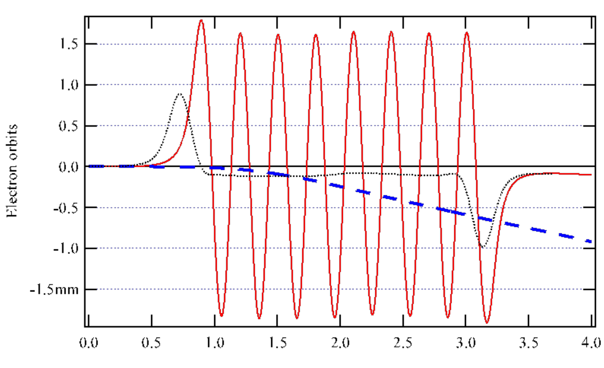

Figure 4: Simulated electron trajectory based on Hall measurements, for K_{RMS}=2. Electron energy is set to 40 MeV.

As is clear from Fig. 3 and Fig. 4, there is a small horizontal field, which is generating a vertical kick of the electron, shown as the dashed curve. This will be corrected using a short horizontal steering coil. The current settings are summarized in Table 3. We see for poles 2 and 4, which are the large end poles, that they are saturating, which agrees with the magnetic modeling efforts.

Table 3: Summary of Optimized Current Settings

K-value	Current settings[A]				
	1	2	3	4	5
0.510	4	14	38	14	4.5
1.00	8.8	27	75	27.5	8.8
2.00	16.55	52	150	52	15.85
3.99	34	105	300	105	33.4
7.76	68	226	625	228	68.3

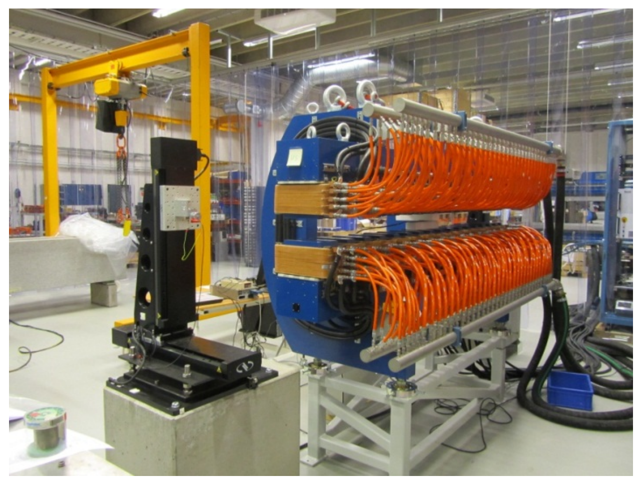

Figure 5: Electromagnetic wiggler during the testing stage, at the Danfysik facility.

CONCLUSION

We have presented the magnetic design and results for the 300 mm electromagnetic wiggler to be used at ELBE. We find that the device performs according to the design, and meets the agreed specifications at all points.

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